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The Bryological Characteristics of the Polish Loess Area

Бриологическая характеристика лёссов в Польше

Bryologiczna charakterystyka lessów w Polsce

INTRODUCTION

Scientific literature concerning especially the occurrence and environment in which mosses and liverworts can exist is not voluminous. A few Polish (Szafran 52, 53, Wacławska 58, 59; Karczmarz 24; Karczmarz and Kuc 25; and Kuc 31—35), Czechoslovakian (Podpěra 43) and Hungarian (Boros and Polgar 3; and Boros 4) workers offer some general information concerning the connection existing between the occurrence of some moss species and the distribution of loess. Even less is known about the liverworts (Szweykowski 56). Certain species of mosses occurring on loess have sometimes been called steppe mosses or xerothermical mosses (Amann 2; Gams 17), but nothing has been said about the soil on which they can grow.

Kraus (30), followed by Kozłowska (28), Dziubałtowski (11); Motyka (41), Fijałkowski (12) Fijałkowski and Izdebski (13) was among the first workers to study the conditions under which the flowering plants exist in loess areas. These studies are valuable because in many cases the commonest xerothermical moss species growing on the slopes of loess gorges have been listed in the phytosociological surveys on which they are based. The species included are the common ones: *Brachythecium albicans*, *Camptothecium lutescens*, *Campylium chrysophyllum*, *Thuidium abietinum*, *Thuidium recognitum* and *Tortula ruralis*.

METHODS AND OBJECTIVES

The studies, reported in this paper, were carried out with the main objective of gaining knowledge of the moss flora of the Polish loess areas, and of the ecological factors which determine the distribution of these species in such areas as well as their special adaptation to environment. For a correct assessment of the number of moss species and the environment in which they occur a systematic field research was conducted during three different seasons of the years 1957—60, with the exception of the later months of winter when it snowed heavily. To characterize the moss communities growing on steep loess walls 23 phytosociological surveys were made. The number seemed sufficient to obtain conclusive results, since neither were there many differences among the moss communities occurring in these areas nor was their number so high as to make their species-wise segregation difficult. Such conclusion was reached during a preliminary field examination. Each phytosociological survey was taken in the form of a square measuring from 0.5 to 1.0 square meter, each entirely devoid of higher vegetation. In some samples, besides moss, liverwort species were also taken into consideration, while the lichen flora, which, according to some authors (Gams 19; and Klement 26) forms totally different sort of communities, was totally neglected. For large scale comparison squares with an approximate area in square meter were taken. Here not only the angle of the steepness of the land was noted, but also data concerning the contents of $CaCO_3$ in the loess of these areas were collected. Unfortunately, because of the unavailability of the necessary apparatus the degree of humidity and the amount of light and heat received by the loess walls were not measured. Braun-Blanquet's seven-degree scale as adapted by Szafran (52) was used to define the quantitative relationship and the companiability of the species. The moss species which could not be identified in the field because their sporogones were weakly developed or lacking were brought to the laboratory in separate labelled bags and studied later.

Bryogeographical analysis has been done according to the method of Szafran (52) and Amann (2) and Herzog (22), while for charting the occurrence of the species help was sought from Podpěra's Conspectus Muscorum Europaeorum. The names of the species found, together with the geographical elements are given in text. Each of the species has been classified from the bryogeographical point of view.

A separate table (No. 2) contains the number and percentage of species for each geographical element. Bryogeographical analysis of the species has been added.

A separate table (No. 1) contains the number and percentage of species for each geographical element. Bryogeographical analysis of the species has been added.

To illustrate the functioning of some ecological phenomena observed in the species of mosses forming communities with *Tortula Velenovskyi* a diagram has been added (Fig. 2); it shows the dependence of the formation of sporogones on the seasons as it was observed in the course of three years. It is an attempt to characterize some of those phenological phenomena in mosses which have not been investigated before. Some results of the observation of the moss flora found in loess areas have been included by the author in previously published papers (Karczmarz 24; Karczmarz and Kuc 25).

LOESS AS ENVIRONMENT IN MOSS LIFE

Loess areas are mainly found in the south-eastern parts of Poland (Fig. 1). Their distribution is very similar to the distribution of the older calcium rock in Pogórze and in the area of the Central Polish Uplands (Kuźniar 36; Samsonowicz 45; Malicki 39; and Dylik 10). The western and central parts of the loess area in Poland have been treated as a separate geobotanical region called the Loess Uplands (Szafer 49). The region has been divided into three districts: the Michów — Pińczów district, the Staszów district and the Opatów-Sandomierz district. The loess area of the Lublin Upland has been left out. This does not seem justified, because with regard to its origin, morphology and vegetation this region is similar to other loess regions (Fijałkowski and Izdebski 13). The moss flora of this region also shows similarities with the moss flora of the other loess regions (Karczmarz 24; Karczmarz and Kuc 25; Kuc 34).

Loess, as rock, is not a uniform formation in the whole Polish land. Besides typical loess, with its characteristic breakability, there occurs also similar loess and the so-called slope loess (Dobrzański and Malicki 9; Malicki 39). The characteristic feature of the loess soil is its contents of $CaCO_3$, which is sometimes as high as 19.0 per cent. Upper loess, sandy loess and loamy loess contain less $CaCO_3$, usually from 6.0 to 9.0 per cent but sometimes even below 3.0 per cent (Tokarski 57; Dobrzański 7). The reason for this difference is this: in the illuvial process $CaCO_3$ is easily washed out. This difference is reflected in the character of the vegetation. In the places where the process is intense there appear such species as *Jasione montana*, *Juniperus communis*, *Sarathamnus scoparius*, or sometimes *Calluna vulgaris*, from mosses *Dicranum scoparium*, *Entodon Schreberi*, *Hylocomnium splendens*, *Scleropodium purum* occur. This interesting phenomenon

was noted by Kozłowska (28), Motyka (41) and Fijałkowski (12). It is also known that loess containing large quantities of biologically active $CaCO_3$ favours abundant occurrence of calciphilous species, among them also steppe species. According to the ecological characterization of the species of mosses found on loess, 40 par cent of the total number of 115 species are the species regarded as calciphilous or facultatively calciphilous (Amann and Meylan 1; Amann 2, and Herzog 22). The presence of $CaCO_3$ in loess soil is of very high significance for the distribution and the growth of mosses, especially the calciphilous species which can grow on calcium-containing soil as well as on loess. These species include: *Aloina brevirostris, A. rigida, Barbula convoluta, B. cylindrica, B. fallax* (often as var. *brevifolia), B. lurida* ssp. *cordata, B. rigidula, Phascum curvicollum, Pottia bryoides, P. intermedia, P. lanceolata* and others.

Loess soils have their specific type of water relationship and this is a factor that controls the occurrence of special vegetation. Rain water flows off the surface but some part of it sinks deep into the soil and is thus unavailable to the plants with short root systems (Dobrzański 8). Mosses and lichens can use it only in the months of heavy rainfalls, chiefly in the autumn and spring. That is why these periods are the periods of their fastest development. The highest degree of humidity is found on north and north-eastern slopes, since they receive minimum light and heat. In most cases those slopes are covered by shrubs or deciduous forests with trees such as hornbeams, wild linden and some shrubs. The southern and south-eastern slopes receive more heat throughout the year and so they are relatively dry and warm. Therefore they are rich in xerothermical species closely related to the community with *Prunetum fruticosae* and *Festuca vallesiaca-Erysimum crepidifolium* (Kozłowska 28; Dziubałowski 11; Fijałkowski and Izdebski 13). Because of the presence of grasses and shrubs and because of the dryness of the soil the moss species here have very difficult conditions for their growth. The species that grow here on moss level are: *Brachythecium albicans, B. glareosum, Camptothecium lutescens, Campylium chrysophyllum, C. hispidulum* var. *Sommerfeltii, Eurhynchium pulchellum* var. *praecox, Thuidium abietinum, Th. recognitum, Tortula ruralis.* The species that occur in smaller number are: *Hypnum cupressiforme* var. *lacunosum* and *Rhytidiadelphus triquetrus.* In exposed places one finds the species belonging to the genus *Barbula, Bryum, Polytrichum, Pottia and others.*

As soft rock, loess is subject to erosion, caused chiefly by rain water, and also to solifluxion and suffusion (Malicki 38; Maruszczak 40; and Jahn 23). An important part is also played by the

activity of man. As a result, various erosive forms have developed on loess, among them gorges, steep walls, terraces, cavities and mounds. Each of these form offers a different set of conditions for the growth of moss species. These forms are not permanent and their variety is clearly reflected in the specific composition of the vegetation. For flowering plants the best suited form is loess gorges. Kozłowska (28) has described three different types of gorges on the Miechów Upland. She divided them according to their appearance, age and vegetation. The types are: young, old and the oldest. Field observations make it clear that in the Polish loess area three erosive forms, each important for the growth and distribution of mosses, can be distinguished from the ecological and floral point of view. They are:

1) Steep loess walls
2) Deluvial loess of newly uncovered surface
3) Slopes of loess gorges mastered by flowering plants.

CHARACTERISTICS OF THE MOSS FLORA OCCURRING IN LOESS AREAS

1. Steep loess walls

Loess walls offer special sites to the growth of mosses. They are also very interesting as landscape. The slopes are bare and steep, up to 5—8 metres high, sometimes even as high as 20 metres. The highest and finest of them occur in the district of Sancygniów on the Miechów Upland, in Sandomierz (Queen Jadwiga's Gorge) and in Sąsiadka near Szczebrzeszyn where they reach the height of 35 metres. The gorges occur in typical loess areas where the layer of loess is thick and characterized by good breakability. They differ from the other morphological forms found in loess areas, because they are hardly ever mastered by higher vegetation and so they retain an unchanged surface for a longer time. The falling-off of loess may occur only in the upper portions of the walls, chiefly during heavy rainfalls or at the time of light frosts. The stability of the surface in these form is due to a considerable compactness of their loess particles (Malicki 39; Dylik 10). The comparative stability of the surface of loess walls and their southern exposure favour the growth of characteristic moss flora i.e. one that has peculiar specific composition and special adaptation to environment. The upper parts of the walls are specially exposed to the effects of rain water which causes their washing-off and the falling-off of their surface layer. This makes impossible the germination of the spores and the development of the plants. Consequently, in these parts of the walls one does not find any mosses, liverworts or crustaceous lichens.

On this type of loess land one finds xerothermical moss species *(Bryoxerogeophytia)*, which are the characteristic moss flora of the dry soil and those receiving highest amounts of light and heat. From the bryocenological point of view, G a m s (16) calls these species *Xerogeophytia Ephemerophytia)*. As the loess walls receive comparatively high heat even in winter months, the growth and development of these moss species goes on most of the time and is checked only during heavy snowfalls and severe frost.

Fig. 1. The localities of the occurrence of *Tortula Velenovskyi*

On the southern side of the steep loess walls there grows a very interesting species of moss known as *Tortula Velenovskyi*, representing the pannonian element in the Polish moss flora. In its area of occurrence it grows only on loess surface (Fig. 1). Since this species grows only on typical loess soils, it can be regarded as one of their characteristic species. This view is further supported by the studies carried out by B o r o s and P o l g a r (3), B o r o s (4), W a c ł a w s k a (58) and K u c (35). Poland is the northern boundary of the area where this species occurs, and here it is more abundant than in Czechoslovakia, Jugoslavia and the Hungarian Plain together. *Tortula Velenovskyi* always

occurs in community with xerothermical species like *Aloina brevirostris, A. ericaefolia, A. rigida* (in highest numbers), *Barbula fallax, B. Hornschuchiana, B. lurida* ssp. *cordata, B. revoluta* (very seldom), *B. rigidula, Bryum argenteum, B. caespiticium, B. Funckii* (extremely seldom), *Pterygoneurum pusillum, P. subsessile*, and the liverworts like *Blasia pusilla, Lepidozia reptans, Metzgeria furcata* and others. In Czechoslovakian areas it occurs along with the same type of moss species as in Poland, while in Hungary, in addition to the above mentioned species, species like *Barbula austriaca, Bryum bicolor* and *Endocarpon sorediatum* are also found growing in community with it (Boros and Polgar 3; and Boros 4). *Barbula austriaca*, like *Tortula Velenovskyi*, occurs on the loess but not so frequently.

The full composition of community with *Tortula Velenovskyi* as it occurs in Poland, is given in Table 1. The moss species included in the table form a community which deserves consideration as a separate collection because of its specific composition, ecological needs and area of distribution. This collection includes mainly orthotropical moss species, most of them being members of the order Pottiaceae, which are of a characteristic xerothermical build resulting from their adaptation to environment. The majority of the species forming this community depend for their existence on the loess land and the $CaCO_3$ contents of these soils. These species do not tolerate shade and that is why they are called xero-heliophytical mosses (Frey and Ochsner 14). Compared with the xeromorphic moss species belonging to the pleurocarpous group these species show less dependence upon microclimate and microrelief. As a result of this they can grow in cracks on loess walls and on uneven edges which are specially dry. Their adaptation to dryness is reflected not only in their xerothermical build but also in their small size *(nanism)*. They are also able to assume bud-like appearance during dry periods and can produce a large number of spores in comparatively short time. This type of adaptation helps this species not only to grow under unfavourable conditions but also to spread to other areas. The same principle holds good also when their individual phenological phenomena and the regulation of growth during the whole period of their vegetative activity are considered (Fig. 2). The most intensive growth of the species characteristic of the steep loess wall areas takes place in Poland during two seasons. The first season begins near the end of March and continues to the middle of June, or not much longer. In exceptional cases, when there are frequent rainfalls, it lasts until July. The second season starts at the beginning of September and continues to the end of December, when the temperature drops and the snow falls. The forming of the sporo-

gones takes place twice during the year: at the beginning of spring and autumn. The factors which influence the formation of sporogones are temperature and humidity. Only when there is a minimum of rainfall at the beginning of autumn, the duration of the second season is delayed until later months. The time of the formation and ripening of the sporogones of the species growing on the southern steep loess walls is similar in nearly all the species. Under favourable conditions, that is in optimum temperature and sufficient humidity, the duration

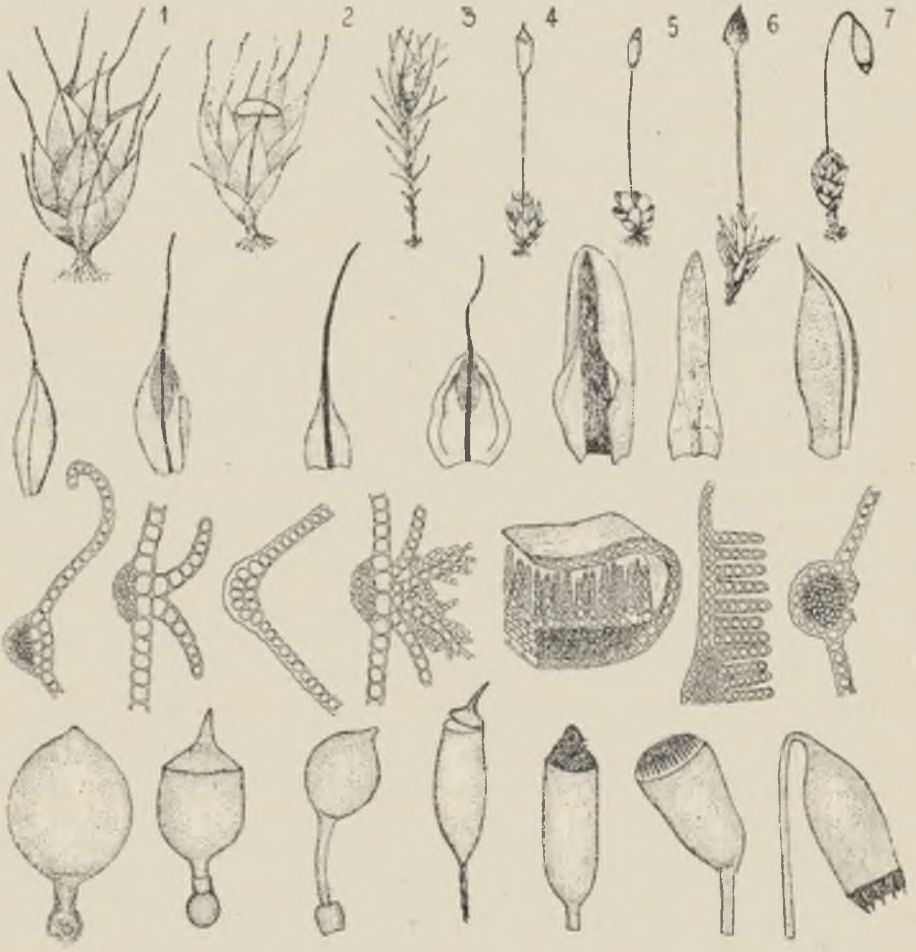

Fig. 2. Musci which belong to the *Bryoxerophytia* group *(crassoxero-nania);* 1 — *Phascum acaulon,* 2 — *Pterygoneurum subsessile,* 3 — *Pleuridium alternifolium,* 4 — *Pterygonevrum pusillum,* 5 — *Aloina rigida,* 6 — *Pogonatum nanum,* 7 — *Bryum Funckii.* Under each habitus of species there are placed in turn: leaf, leaf in transversal section, capsule of sporogone.

Reproduced from Marian Kuc: Mchy kserofityczne *(Bryoxerophyta)* „Wszechświat", 1957, No 11.

of the period is from 3 to 4 weeks. The species belonging to the genus *Barbula* and *Bryum* take a longer time (from 4 to 5 (6) weeks), while the sporogone formation and ripening in species such as *Aloina*, *Phascum*, *Pterygoneurum* and *Tortula Velenovskyi* takes from 3 to 4 weeks, if the conditions are favourable.

Sometimes there occurs on steep loess walls a smaller moss community with *Aloina rigida*. This community is of less permanent nature than the community formed by *Tortula Velenovskyi*. Most often this community is formed by species such as *Aloina ericaefolia*, *A. rigida*, *Barbula fallax*, *B. unguiculata*, *Bryum argenteum*, *B. caespiticium*, *Encalypta vulgaris*, *Pottia intermedia*, *P. truncatula*, *Pterygoneurum pusillum* and less frequently *Tortula subulata* or underdeveloped specimens of *Brachytecium albicans*, *Thuidium abietinum*. *Th. recognitum*. These communities can grow not only on the southern walls but also on those facing south-east and north-west. A characteristic feature of this community is the increasing number of pleurocarpous mosses, which never form sporogones. This community grows most abundantly in the months of spring. In its specific composition it is similar to the community described under the same name by S z a f r a n (52) and growing on the rocky loess areas of the southern part of Jura Krakowsko-Wieluńska.

Wherever the loess depositions are found, some species of lichen, such as *Solorinella asteriscus* which grows in the Czechoslovakian loess areas, are also known to grow (S u z a 47). On southern loess walls in the pannonic area in Czechoslovakia this species forms microassociation with *Endocarpon pusillum*, *Caloplaca pyracea*, *Lecanora crenulata* for. *argillicola*, *L. lentigera*. From among the mosses there occur: *Camptothecium lutescens*, *Entodon orthocarpus*, *Thuidium abietinum*, and in exposed places *Barbula fallax* var. *brevicaulis*, *Bryum argenteum*, *Phascum Floerceaum*, *Pterygonereum pusillum*, and *P. subsessile*.

2. D e l u v i a l l o e s s o f n e w l y u n c o v e r e d s u r f a c e

This kind of locality includes: loess at the foot of slopes, at the bottom of loess walls and at the edges of loess basins. They all play a similar role in the growth and distribution of the mosses in the whole area. Their characteristic feature is a constant change of surface which makes impossible the settlement of biennial or triennial mosses. Their constantly changing upper layer creates favourable conditions for the occurrence of numerous acrocarpous mosses of the *Ephemorophytes* group (according to G a m s *Ephemerophytia)*. The species of mosses that are found here are: *Catharinea angustata*, *C. tenella*, *C. undulata*, *Ceratodon purpureus*, *Encalypta vulgaris*, *Erythrophyllum rubellum*, *Fis-*

sidens bryoides, F. taxifolius, Funaria fascicularis. F. hygrometrica, Leptobryum pyriforme, Mniobryum albicans, M. carneum, Phascum acaulon, Ph. *curvicollum, Physcomitrium pyriforme, Ph. eurystomum, Pleuridium alternifolium, Pogonatum nanum, P. urnigerum, Pterygoneurum pusillum, P. subsessile,* and *Tortula subulata.* Besides those, one finds here the following species in large numbers: *Barbula convoluta, B. fallax, B. rigidula, B. unguiculata, Bryum argenteum, B. caespiticium, B. pallens, B. pallescens, Dicranella crispa, D. heteromalla, D. rubra, D. rufescens, D. Schreberi, D. subulata, D. vaginalis, Pohlia annotina, P. cruda, P. grandiflora, P. nutans.* The species of the genus *Pottia* represented here are: *Pottia bryoides, P. Davalliana, P. intermedia, P. lanceolata, P. truncatula, P. Starceana* (rarely). Rare specimens of the moss flora such as: *Acaulon muticum, A. triquetrum, Ditrichum tortile, D. vaginans, Funaria dentata, Pohlia bulbifera, P. elongata, Pyramidula tetragona,* are very seldom found on deluvial loess. They have very few localities in the loess area of Poland. *Funaria dentata* has been found in Podgrodzie near Ćmielów on the Sandomierz Plateau (K u c 32). Another very rare species, *Pyramidula tetragona,* has so far been found only in one locality in the vicinity of Grabowiec, in the eastern part of the Lublin Plateau (K a r c z m a r z, K u c 25). The pleurocarpous species which grow most abundantly are: *Brachythecium albicans, B. glareosum, B. salebrosum, Camptothecium lutescens, Campylilum chrysophyllum, C. hispidulum* var. *Sommerfeltii, Hypnum arcuatum, Thuidium abietinum, Th. delicatulum, Th. recognitum.* The majority of the above-mentioned species occurring on deluvial loess do not conclude their cycle of development in the yearly vegetative period. Their development usually comes to an end after they have formed assimilating gametophytes. Microscopic examination of a number of specimens collected from various localities revealed the presence of poorly developed antheridia and archegonia. The sets of many of the examined specimens were underdeveloped or wasted and lacking capsules. Their further development was probably checked by long-lasting dry weather.

In such localities or in similar ones one also finds some liverworts such as *Blasia pusilla, Lepidozia reptans, Preissia quadrata, Riccia multifida, Mathodecka platyphylla,* or, in the vicinity of chalk rocks, *Grimaldia fragrans* (P a ł k o w a, K u c 42). *Grimaldia fragrans* is a xerothermic species generally found on calcium rocks. It rarely occurs on loess soil. One of the more interesting species of liverworts is *Leiocolea heterocolpos;* it belongs to mountain species (G a m s 18). A lowland locality of this species has been discovered on loess soil on Roztocze near Zwierzyniec (S z w e y k o w s k i 56). The occurrence of such

an interesting species on loess soil is doubtless due to its calciphilous requirements.

As higher plants settle gradually in these localities, the heliophylous species of mosses disappear by degrees leaving room for the species characteristic of thickets and deciduous forests. Only some of them, such as *Catharina* undulata, *Fissidens taxifolius* and *Pohlia nutans* can survive the change and enter new communities without difficulty.

3. Slopes of loess gorges mastered by flowering plants

The slopes of gorges are most frequently covered by shrub plants; grass communities are found on them much less often. Southern slopes are usually covered by grasses of xerothermic character or else by shrub communities including shrubs such as *Betula verrucosa, Cornus sanguinea, Crataegus monogyna, Evonymus europaea, E. verrucosa, Frangula alnus*, and in dry places with plenty of sunshine — *Prunus spinosa, Rosa canina, R. dumetorum, R. glauca*, as well as *Cerasus fruticosa*, though the last one less frequently. The slopes of most recent formation are covered by synanthropic species of verdurous plants, the species of moss that are found there in great numbers are: *Bryum argenteum, Catharinea undulata, Ceratodon purpureus, Funaria hygrometrica, Pohlia nutans*. Gorges with gently sloping walls of older formation are covered by dense shrubs and deciduous forests. The oldest forests in the loess area of the Lublin Plateau are found near its edge in the vicinity of Lublin (Fijałkowski 12), and some on the Miechów Plateau (Kozłowska 28). The species that usually occur on the tree level are: *Carpinus betulus, Fagus silvatica, Quercus robur, Tilia platyphyllos*, and, in some regions, also *Pinus silvestris*. The specific composition of the layer of mosses is very similar to the specific composition of the mosses found in shrub communities. The epiphytic species occurring here as well as the species found on decayed tree trunks have been characterized in detail in bryological papers discussing separate regions. Among xerothermic plants growing on slopes there occur commonly xerothermic species of mosses such as *Brachythecium albicans, Camptothecium lutescens, Campylium chrysophyllum, C. hispidulum* var. *Sommerfeltii, Eurhynchium pulchellum* var. *praecox, Hypnum cupressiforme* var. *lacunosum, Thuidium abietinum, Th. recognitum, Tortula ruralis*, and very seldom, *Brachythecium glareosum*. In exposed places or on the verge of thickets one finds *Eurhynchium Swartzii* var. *abbreviatum* and var. *atrovirens, Hypnum arcuatum, Rhytidiadelphus squarrosus, R. triquetrus*, and in more humid places *Cirriphyllum piliferum* as well as *Thuidium deli-*

catulum. The species of mosses which go through their full cycle of development in comparatively short time grow on loess soil devoid of flowering plants, on the edges of gorges, pits and cavities. The species belonging here are: *Catharinea angustata*, *C. undulata*, *Barbula fallax*, *Pogonatum urnigerum Polytrichum piliferum*, *Weisia microstoma*, *W. viridula* and others. *Buxbaumia aphylla*, a species commonly found in dry pine woods on sandy soil, rarely occurs on exposed loess. Some species of mosses can form small communities in shady and humid places on exposed loess or on loess covered by a thin layer of humus. In this kind of localities one usually finds species such as: *Brachythecium rutabulum*, *B. Starkei*, *Catharinea undulata*, *Dicranella heteromalla*, *Dicranum scoparium*, *Eurhynchium Zetterstedtii*, *Hypnum cupressiforme*, *Mnium affine* var. *elatum*, *M. cuspidatum*, *Plagiothecium Roeseanum*, and the liverworts such as *Conocephalum conicum and Plagiochila asplenioides*.

The influence of anthropogenically changed loess soil on the development of the moss flora can vary according to the age of the soil and to the way in which it was formed. In cultivated fields and in those that are left fallow there grow the following species: *Barbula fallax*, *B. unguiculata*, *Bryum argenteum*, *Ceratodon purpureus*, *Pohlia annotina*, *Pottia truncatula*, and in early spring — *Funaria fascicularis* and *Pottia Davalliana*. A community that consists of few species, all of nitrophilous requirements often develops in synanthropic and humid places where numerous nitrogen compounds collect. This community includes *Bryum argenteum*, *Ceratodon purpureus*, *Funaria hygrometrica*, and *Pohlia nutans*. It usually develops on the edges of roads, in roadside ditches, on trodden ground.

WAYS OF ADAPTATION OF THE MOSSES

The mosses growing on loess soil have special ways of adapting themselves to environment. Mention has been made that this adaptation manifests itself in their appearance, in the structure of their leaves, in their development, in the manner of their throwing out the spores, and, finally, in some of their phenological characteristics.

The species of mosses growing on bare loess walls of a southern exposure are characterized by very small size and a peculiar anatomic structure of the leaves (Fig. 3). The leaves of these species are folded into a kind of hood and covered with a thick cuticle. The blade of the leaf curls as it loses its content of water, and as a result the plant looks bud-like decreasing thus its surface of transpiration. This can be very well observed in the species of the genus *Aloina*, *Phascum*, *Pterygoneurum* and *Tortula Velenovskyi*. This peculiar kind of adapta-

tion reflected in the small size of the plant is sometimes termed *nanism* in case of mosses *(Nanogeophytia)*. In other species of the genus *Barbula* the leaves are capable of performing hygroscopis movements responding readily to the presence of humidity in the atmosphere. In other species the rib sticks out of the leaf blade in the form of hyaline hair, sometimes dented at the top. This kind of leaf structure probably protects the plant against excessive exposure to sunshine. It may also help it to absorb more humidity from the atmosphere (G o e b e l 21; H e r z o g 22). This kind of structure is found in many species of the genus *Pterygoneurum*, *Tortula ruralis* and others. Many species are specially adjusted so that they may increase their assimilating and absorbing surface (absorbing rain water). The adjustment consists in producing by the leaves of these species the so-called assimilators or cells performing assimilation. The cells make several layers on the

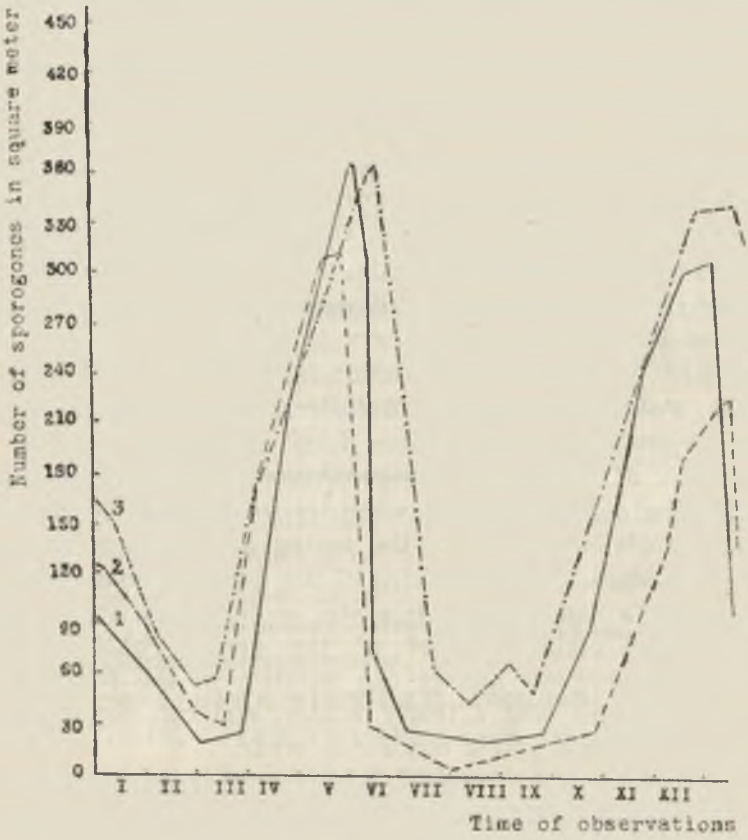

Fig. 3. The formation of sporogones of the species growing in community with *Tortula Velenovskyi* on the Lublin Upland (Izbica) in the years: 1958 (1), 1959 (2), 1960 (3)

ventral side of the leaf and are filled with a great number of green corpuscles. They occur in the species of the genus *Aloina* and *Pterygoneurum*. This kind of adaptation found in the mosses that grow on steep loess walls makes it possible to include them in the group of *Xerogeophytia* (G a m s 16). The group deserves attention because of the interesting structure of its capsule. With regard to the way of opening the capsule these mosses constitute a group of the so-called cleistocarpous mosses. In many of them the capsule is concealed among the leaves and is always without the lid and the peristome. Only in some is the lid outlined indistinctly on the capsule. The capsule opens by rhexochetion i.e. its walls become torn or decayed. The falling out of spores by rhexochetion takes place in mosses that have no peristome, i.e. species such as *Acaulon muticum*, *A. triquotrum*, *Pascum acaulon*, *Ph. cuspidatum*. The phenomenon of rhexochetion in mosses is connected with their ability to master the soil quickly in unfavourable conditions (S z a f r a n 54). The spores are scattered by the wind (anemosporia) or by the water (hydrosporia). In accordance with the circumstances both ways of spreading the spores can be serviceable, one after the other, in case of the same species. Rainfalls are the factor that determines the order of the two ways. In case of species such as *Pottia bryoides*, *P. lanceolata*, *P. truncatula*, *Pterygoneurum pusillum*, *P. subsessile*, all of them producing spores in large numbers, the scattering of spores is helped by insects, chiefly ants (zoosporia).

Another sign of adaptation to dryness can be observed in the species of moss that develop multipliers (gemmules) as organs of vegetative reproduction. These organs occur in *Barbula lurida* ssp. *cordata*, *B. rigidula*, *Pohlia annotina*, *P. bulbifera*, *P. grandiflora*. The mosses that have multipliers very seldom form sporogones in this country.

The mosses of the group *Xerogeophytia* include annual and perennial species the development of which is most intensive in the period of heaviest rainfalls, that is in the spring and autumn. Some species of loess soil mosses, e.g. the species of the genus *Aloina*, *Pottia*, *Pterygoneurum* have a rest period while still in the spore stage. Most mosses, among them certain species of the genus *Pohlia*, *Bryum*, and nearly all pleurocarpous mosses can survive, in the form of gemetophyte, a dry summer and a frosty winter, and can begin their development as soon as favourable conditions occur.

The formation of sporogones depends on humidity and, among others, on rainfalls (H e r z o g 22, S z a f r a n 54). Sporogones are formed principally in two periods: the spring and the autumn period. If there are heavy rainfalls at the end of the spring or at the beginning of summer, or heavy rainfalls and snowfalls during autumn and

winter, both periods of sporogone formation can be delayed. Similarly, some species can form sporogones during a wet summer. This happened in July and August of 1960 (Fig. 3).

A slightly different kind of adaptation is found in pleurocarpous mosses. On loess soil these rarely form sporogones, because their antheridia and archegonia are not fully formed or else die away as a result of insufficient humidity. The cells of their leaf blades develop numerous nipples. The tip of the leaf is usually elongated and has a hair. The growth of leaves is dense which prevents excessive transpiration.

GEOGRAPHICAL ELEMENTS

115 species of moss have been found to occur in the loess area of Poland. Their distribution is either directly connected with loess soil or they find there their optimum conditions for development, hence most of them have the greatest number of localities in this area. According to the classification devised by Szafran (52) they represent ten geographical elements (Table 2). Elements such as boreal, oceanic and pancontinental are represented by several geographical groups.

1. Boreal element

a. Panboreal group. It is the most numerous group in the element and includes certain species which are rare in our flora as well as some very common ones such as *Aloina brevirostris, Barbula convoluta, B. fallax, B. reflexa, B. rigidula, B. unguiculata, Buxbaumia aphylla, Campylium chrysophyllum, C. hispidulum* var. *Sommerfeltii, Catharinea undulata, Dicranella crispa, D. rubra, D. Schreberii D. subulata, D. vaginalis Ditrichum tortile, D. vaginans, Encalypta contorta, E. vulgaris, Eurhynchium strigosum, Fissidens bryoides, Mnium cuspidatum, M. punctatum, M. stellare, Pogonatum urnigerum, Pohlia annotina, P. bulbifera, Rhytidiadelphus triquetrus,* and *Thuidium recognitum.*

b. Euroasiatic group. *Brachythecium glaresum, Bryum Funckii,* and *Pohlia grandiflora.*

c. Euro-North-American group: *Ditrichum homomallum.*

2. Holarctic element: *Bryum pallescens, Erhytrophyllum rubellum, Rhytidiadelphus squarrosus.*

3. Arctico-alpine element: *Encalypta ciliata.*

4. Sub-arctic element: *Bartramia ithyphylla.*

5. Pancontinental element:

a. Panboreal group. It is represented by species such as *Amblystegium serpens, Brachythecium rutabulum, Bryum caespiticium, B. pallens, Hylocomnium splendens, Hypnum cupressiforme, Mniobryum albicans, Mnium rostratum, Pohlia cruda, P. elongata, P. nutans, Po-*

Table 2

Geographical elements	Number of species	Percentage
1. Boreal		
a. Panboreal group	30	26.0
b. Euroasiatic group	3	2.6
c. Euro-North-American group	1	0.9
2. Holarctic	3	2.6
3. Arctico-alpine	1	0.9
4. Subarctic	1	0.9
5. Pancontinental		
a. Panboreal group	15	13.0
b. Holarctic group	4	3.5
c. Euroatlantico-Mediterranean group	6	5.2
d. Euroatlantic group	2	1.7
6. Cosmopolitan	4	3.5
7. Euroasiatico-African	1	0.9
8. Oceanic		
a. Euroatlantic group	13	11.4
b. Euroatlantico-Mediterranean	18	15.6
c. Euroatlantico-Mediterranean-West American	5	4.9
d. Euroatlantico-boreal group	1	0.9
e. Euroatlantico-Mediterranean-East Asian-North American group	2	1.7
9. Mediterranean-Central Asian	4	3.5
10. Pannonian	1	0.9
Total	115	100.0

lytrichum juniperinum, *Pottia truncatula*, *Thuidium delicatulum* and *Weisia viridula*.

b. Holarctic group: *Brachythecium salebrosum*, *Entodon Schreberi*, *Leptobryum pyriforme* and *Polytrichum* piliferum.

c. Euroatlantico-Mediterranean group: *Aloina aloides*, *Eurhynchium Swartzii*, *Physcomitrium eurystomum*, *Pottia intermedia*, *P. Starkeana* and *Tortula ruralis*.

d. Euroatlantic group: *Dicranella heteromalla* and *Polytrichum attentuatum*.

6. Cosmopolitan element. It includes the commonest species found in loess areas: *Bryum argenteum, Ceratodon purpureus, Funaria hygrometrica* and *Tortula ruralis.*

7. Euroasiatico-African element: *Pogonatum aloides.*

8. Oceanic element:

a. Euroatlantic group: *Brachythecium albicans, Catharinea angustata, Cirriphyllum piliferum, Dicranella rufescens, Diphyscium sessile, Eurhynchium Zetterstedtii, Fissidens taxifolius, Mnium hornum, Plagiothecium Roeseanum, Pleuridium alternifolium, Pottia bryoides, Pterygoneurum subsessile, Scleropodium purum.*

b. Euroatlantico-Mediterranean group: It includes most of the species belonging to the *Pottiaceae group.* They are represented by *Acaulon triquetrum, Barbula Hornschuchiana, B. lurida, Funaria dentata, F. fascicularis, Hypnum cupressiforme* var. *lacunosum, Mniobryum carneum, Mnium undulatum, Phascum acaulon, Ph. curvicollum, Physcomitrium pyriforme, Pleuridium subulatum, Pogonatum nanum, Pottia Davalliana, P. lanceolata, Pterygoneurum pusillum, Weisia crispa, W. microstoma.*

c. Euroatlantico-Mediterranean-West American group: *Acaulon muticum, Aloina ericaefolia, Barbula cylindrica, Camptothecium lutescens, Pyramidula tetragona.*

d. Euroatlantico-Boreal group: *Catharinea tenella.*

e. Euroatlantico-Mediterranean-East Asian-North American group: *Barbula vinealis, Hypnum arcuatum.*

9. Mediterranean-Central Asiatic element: *Aloina rigida, Barbula revoluta, Thuidium abietinum,* Tortula *sublata.*

10. Pannonian element: *Tortula Velenovskyi.*

THE RESULTS OF RESEARCH AND OBSERVATION

The mosses growing in the loess area of Poland include a variety of species. This is the more remarkable that conditions for them are rather unfavourable since the soil is very dry. In the whole area 115 species were found; 91 of them were acrocarpous species and the remaining 24 pleurocarpous. A majority of them are xeromorphic species characterized by a structure that is specially adapted to difficult living conditions. They belong to the group of *Xerogeophytia* which includes 45 per cent of all the species. Like the other species of dry localities, they have a very special cycle of phenological phenomena connected with the formation of the sporogones. The remaining part of the mosses consists of mesothermic or facultatively mesothermic species (Amann et Meylan 1, Amann 2). In the loess area one finds the species characteristic of loess, such as *Tortula Velenovskyi,* or those

which have a preference for loess soil. Thus many of them have the greatest number of localities in this part of the country. They are found chiefly on typical loess, most frequently on steep loess walls. These mosses include numerous species of the genus *Acaulon*, *Aloina*, *Barbula*, *Dicranella*, *Funaria*, *Phascum*, *Pohlia*, *Pottia*, *Pterygoneurum* and *Weisia*. Cosmopolitan species commonly occurring in various localities in this country make only a small per cent of the total number of species found in the area where the research was conducted. It is a distinctive feature of the moss flora of the loess area that the species of the family *Pottiaceae* have a large share in it. It is commonly known that the mosses of this family are most thoroughly adapted to dry conditions (Chen 6). As regards this quality the moss flora of loess areas resembles in many respects the moss flora of the steppe areas in Poland (Szafran 50, 51, Celiński, Filipek 5), as well as the moss of southern and south-eastern Europe (Amann 2, Łazarenko 37, Gams 17, Podpěra 43. Stodieck 46, Koppe 27, Giacomini 20). The other points of similarity are: the occurrence on loess soil of the species from the Mediterranean area, and the occurrence of the species which are commonly found on calcium-containing soil with steppe vegetation. The reason for this is to be sought in large contents of $CaCO_3$ in loess soil. Calciphilous requirements are characteristic of a large proportion of the species (40 per cent). This quality enables many species to be as expansive as they are in mastering new localities.

Loess offers very special localities for the development and distribution of mosses. This is reflected in a variety of ways of their adaptation and in their formation of specific communities. The moss flora developing on loess is of xeromorphic character. Some of the species belong to the so-called ephemerides *(Ephemerophytia)*. Their vegetative period is very brief and usually takes place in early spring or in autumn.

On loess soil three basic groups of localities are usually distinguished; all of them are of importance in the development and distribution of mosses. At the same time, they constitute very distinct geomorphological forms resulting from the processes of erosion. The groups of localities that are distinguished are: 1) steep loess walls, 2) deluvial loess of newly uncovered surface, 3) slopes of loess gorges mastered by flowering plants. The ecological and floral characteristics of these localities were specified in chapters 1—3 of this paper.

As regards bryogeography, the occurrence of the mosses of panboreal and mediterranean groups are characteristic of the loess area. The species belonging to the former group may have reached the loess

area after the receding of the ice cap. Undoubtedly, the same process is taking place now, only to a lesser degree. The latter group, that of the mediterranean mosses, must have come with the floweing plants from the regions of southern Europe. (Szafer 48, Kozłowska 29, Gajewski 15). Another feature of the moss flora of these areas is its conformity with the general character of the flowering plants, which, as it is generally known, have xerothermic character when they occur on southern slopes.

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РЕЗЮМЕ

Лёссы являются своеобразным типом жилища для развивающейся в них бриофлоры. Эти мягкие горные породы легко подвергаются эрозии под влиянием осадковых вод, создавая характерические формы. Каждая из них обладает своеобразными экологическими условиями и поэтому — своеобразным видовым составом мхов. Для развития и размещения мхов в исследованном районе решающее значение имеют три геморфологические формы: 1) крутые лёссовые стены, 2) обвалы со свежей открытой поверхностью, 3) склоны лёссовых оврагов покрытые цветковой растительностью.

Крутые лёссовые стены являются наиболее характерным типом лёссового основания. Они почти лишены высшей растительности. Лёссовые стены, экспонированные к югу, очень сильно освещаются и нагреваются солнцем даже зимой. Получают также очень мало воды из осадков. Это создает особенные условия для развивающихся там типов. Произрастающая на них флора мхов отличается особенной приспособленностью к засухе и сильному облучению. Растущие там виды обладают ксероморфной структурой листьев и своеобразным строением коробочки. Это одно — и двухлетние мхи, переходящие в состояние покоя в сухие времена года (Xerogeophytia). К ним принадлежат: *Aloina brevirostris*, *A. ericaefolia*, *A. regida*, *Barbula fallax*, *B. Hornschuchiana*, *B. lurida* ssp. *cordata*, *B. revoluta*, *B. rigidula*, *Bryum argenteum*, *B. caespiticium*, *B. Funckii*, *Pterygoneurum pusillum*, *P. subsessile*, *Tortula Velenovskyi*.

Заслуживает внимания *Tortula Velenovskyi*, мох являющийся панноньским элементом и произрастающий исключительно на лёссах. Кроме Польши этот мох известен в Чехословакии, Венгрии, Югославии. Этот вид вместе с сопутствующими ему видами создает своеобразное сообщество, которое можно выделить в отдельную ассоциацию (табл. 1).

Осыпи со свежей обнаженной поверхностью имеются чаще всего у оснований склонов и лёссовых стен. К этой группе мест произрастания принадлежит лёссовый делювий. Его поверхность непрерыв-

но изменяется, что позволяет поселяться на нем характерной флоре мхов из группы эфемерофитов (Ephemerophytia). Принадлежащие к ней виды переходят полное развитие в одном вегетационном периоде, некоторые из них заканчивают свое развитие образованием ассимилирующего гамметофита. К этой группе принадлежат: *Catharinea angustata*, *C. tenella*, *C. undulata*, *Ceratodon purpureus*, *Encalypta vulgaris*, *Erhytrophyllum rubellum* а также многие виды из родов *Dicranella*, *Pohlia*, *Pottia*.

Крутые и сухие лёссовые склоны заняты ксеротермической растительностью или кустарниковыми зарослиями. Среди ксеротермической растительности имеются также ксеротермические виды мхов, которые обитают также обычно в степных районах. Это виды *Brachythecium albicans*, *B. glareosum*, *Camptothecium lutescens*, *Campylium chrysophyllum*, *C. hispidulum* var. *Sommerfeltii*, *Thuidium abietinum*, *Th. recognitum*, *Tortula ruralis*.

Относительно высокое содержание $CaCO_3$ в лёссах способствует обитанию многих кальцефильных видов. Из общего числа 115 видов, приуроченных к лёссам или же часто обитающих на них, 40% составляют кальцефильные виды.

В бриочеографическом отношении они представляют десять географических элементов. Чаще всего представлены элементы: бореальный, панконтинентальный и океанический. Очень многочисленной является средиземноморская группа, к которой принадлежат многие кseроморфические и ксеротермические мхи.

STRESZCZENIE

Lessy stanowią bardzo osobliwy typ siedliska dla rozwijającej się na nich bryoflory. Jako utwór miękki, ulegają bardzo łatwo erozji pod wpływem wód opadowych, będącej bezpośrednią przyczyną tworzenia się charakterystycznych form geomorfologicznych. Każda z tych form posiada ze względu na odmienne warunki ekologiczne różny skład gatunkowy mchów. Dla rozwoju i rozmieszczenia mchów na tym obszarze decydujące znaczenie mają trzy grupy form morfologicznych: 1) strome ściany lessowe, 2) usypiska o świeżo odkrytej powierzchni skalnej, 3) zbocza lessowych wąwozów opanowane przez roślinność kwiatową.

Strome ściany lessowe są najbardziej charakterystyczną formą na podłożu lessowym. Są one prawie zupełnie pozbawione roślinności wyższej. Ściany lessowe o wystawie południowej są bardzo silnie naświetlane i ogrzewane nawet w porze zimowej. Otrzymują również

bardzo mało wody pochodzącej z opadów. Stwarza to osobliwe warunki dla rozwijających się na takich ścianach mchów. Występująca na nich flora mchów charakteryzuje się osobliwymi przystosowaniami do suszy i naświetlenia. Rosnące na takich stromych ścianach lessowych — gatunki mchów odznaczają się kseromorficzną budową liści i osobliwą budową puszki. Są to mchy jedno- lub dwuletnie, przechodzące stan spoczynku w okresie suszy (Xerogeophytia). Należą do nich wśród mchów spotykanych na lessowych obszarach Polski: *Aloina brevirostria, A. ericaefolia, A. rigida, Barbula fallax, B. Hornschuchiana, B. lurida* sp. *cordata, B. revoluta, B. rigidula, Bryum argenteum, B. caespiticium, B. Funckii, Pterygoneurum pusillum, P. subsessile, Tortula Velenovskyi.* Na uwagę zasługuje *Tortula Velenovskyi*, mech reprezentujący element pannoński i występujący wyłącznie na podłożu lessowym. Poza Polską *Tortula Velenovskyi* — znana jest z Czechosłowacji, Węgier i Jugosławii. Gatunek ten wraz z towarzyszącymi mu tworzy charakterystyczne zbiorowisko, które może być wyróżnione jako osobny zespół (tab. 1).

Usypiska o świeżo odkrytych powierzchniach występują najczęściej u podstaw zboczy i ścian lessowych. Do tej grupy siedlisk należą także deluwia lessowe. Powierzchnie takie są ustawicznie zmieniane i odświeżane, co powoduje osiedlanie się na nich charakterystycznej flory mchów z grupy efemerofitów (Ephemerophytia). Należące do niej gatunki przechodzą pełny rozwój w jednym okresie wegetacyjnym. Niektóre z nich kończą swój rozwój z chwilą wykształcenia asymilującego gametofitu. Do tej grupy należą: *Catharinea angustata, C. tenella, C. undulata, Ceratodon purpureus, Encalypta vulgaris, Erhytrophyllum rubellum* oraz liczne gatunki rodzaju *Dicranella, Pohlia, Pottia.*

Strome i suche zbocza lessowe porasta roślinność kserotermiczna, bądź krzewiaste zarośla. Wśród roślinności kserotermicznej występują także kserotermiczne gatunki mchów, pospolite również na obszarach stepowych. Rosną tu *Brachythecium albicans, B. glareosum, Camptothecium lutescens, Campylium chrysophyllum, C. hispidulum* var. *Sommerfeltii, Thuidium abietinum, Th. recognitum, Tortula ruralis.*

Stosunkowo wysoka zawartość $CaCO_3$ w podłożu lessowym powoduje występowanie licznych gatunków kalcyfilnych. Z ogólnej liczby gatunków przywiązanych do lessów lub często na nim występujących w ogólnej liczbie 115 gatunków — 40% stanowią gatunki kalcyfilne lub względnie kalcyfilne.

Pod względem bryogeograficznym gatunki te reprezentują dziesięć elementów. Najliczniej jest reprezentowany element borealny, pankontynentalny i oceaniczny. Bardzo liczna jest grupa śródziemnomor-

ska, do której należy większość mchów kseromorficznych i kseroter-micznych.

OPIS RYCIN

Ryc. 1. Odkryte stanowiska *Tortula Velenovskyi.*

Ryc. 2. Grubolistne mchy karłowate *cresso-xero-nania): 1 — Phascum acaulon,* 2 — *Pterygoneurum subsessile,* 3 — *Pleuridium alternifolium,* 4 — *Pterygoneurum pusillum,* 5 — *Aloina rigida,* 6 — *Pogonatum nanum,* 7 — *Bryum Funckii.* W kolumnie pionowej pod każdym pokrojem gatunku zamieszczone są kolejno: liść, jego przekrój poprzeczny, puszka sporogonu.

Ryc. 3. Wytwarzanie sporogonów przez gatunki należące do zespołu *Tortula Velenovskyi* na Wyżynie Lubelskiej (Izbica) w latach: 1958 (1), 1959 (2), 1960 (3).

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TABLE 1. COMMUNITY WITH TORTULA VELENOVSKYI — ZBIOROWISKO Z TORTULA VELENOVSKYI

No. of survey Numer zdjęcia	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Stałość — (Constancy)
Contents of $CaCO_3$ Zawartość $CaCO_3$	15.3	14.4	9.8	17.3	16.0	17.6	18.6	16.8	15.6	18.0	17.0	13.1	16.0	10.2	13.8	13.0	10.0	13.1	14.5	11.5	13.5	17.5	16.6	
Exposition Ekspozycja	S	S	S	SO	SO	SO	S	SO	SO	S	S	S	S	S	SO	SO	S	S	S	S	S	S	S	
Inclination Nachylenie	90	85	85	85	85	80	90	85	90	90	85	85	80	85	85	85	85	85	85	85	80	80	85	
Cover in % Pokrycie w %	65	70	70	65	65	95	65	50	80	45	60	75	65	75	65	65	40	35	65	60	55	65	55	
Surface of survey in m^2 Powierzchnia zdjęcia w m^2	0.5	0.75	0.5	0.5	0.5	0.5	1.0	0.5	0.5	0.75	0.75	0.75	0.5	0.5	1.0	0.5	0.5	0.75	0.75	1.0	1.0	1.0	0.75	
Characteristic species of the community Gatunki charakterystyczne zbiorowiska																								
Tortula Velenovskyi	2—3	2—3	2—2	2—3	1—2	4—4	3—4	2—3	3—4	1—1	2—3	2—3	3—4	3—3	1—2	1—2	1—2	2—3	1—2	2—3	1—2	1—2	1—2	IV
Aloina rigida	—	+—1	1—2	+—1	1—2	1—2	2—3	1—1	1—2	1—2	1—2	2—3	1—2	1—2	—	1—1	2—2	+—1	—	+—1	1—2	1—2	+—1	III
Aloina ericaefolia	—	+—1	—	+—1	+—1	+—1	—	—	+—1	—	+—1	+—1	—	+—1	+—1	—	—	+—1	—	—	—	—	+—1	II
Pterygoneurum pusillum	1—2	1—2	+—1	1—2	1—2	+—1	+—1	—	1—2	1—2	+—1	+—1	+—1	1—2	+—1	+—1	—	+—1	—	+—1	—	—	+—1	II
Pterygoneurum subsessile	1—2	—	—	1—1	—	+—1	—	+—1	—	—	—	—	—	—	+—1	—	—	+—1	—	—	—	—	1—1	II
Barbula rigidula	1—2	—	—	+—1	+—1	2—3	1—2	—	—	1—2	1—1	1—1	—	—	—	+—1	—	—	1—2	2—2	+—1	—	2—3	II
Barbula fallax	1—2	2—3	1—2	—	1—1	+—1	1—2	—	+—1	—	1—2	—	+—1	1—2	+—1	—	+—1	+—1	1—2	1—2	+—1	+—1	+—1	II
Accompanying species Gatunki towarzyszące																								
Bryum argenteum	1—1	+—1	+—1	—	+—1	—	+—1	+—1	—	+—1	+—1	—	—	+—1	—	+—1	—	—	—	—	+—1	—	—	I
Bryum caespiticium	+—1	+—1	1—2	—	—	—	+—1	—	—	—	—	+—1	+—1	—	—	—	+—1	—	+—1	+—1	—	+—1	—	I
Pottia truncatula	—	+—1	—	—	—	—	+—1	—	1—1	—	—	—	—	—	+—1	—	—	—	—	—	+—1	—	—	I
Pottia intermedia	—	—	—	—	+—1	+—1	—	—	—	—	—	—	—	+—1	—	—	—	+—1	—	—	—	—	—	I
Barbula Hornschuchiana	—	—	—	—	—	1—1	—	+—1	—	+—1	+—1	—	—	—	—	—	—	—	—	+—1	—	—	—	I
Barbula convoluta	—	—	—	—	—	+—1	—	—	+—1	1—1	+—1	—	—	—	—	—	—	—	—	—	—	—	+—1	I
Barbula revoluta	+—1	—	—	—	—	—	+—1	—	+—1	+—1	—	—	—	—	—	—	—	+—1	+—1	—	—	—	—	I
Barbula lurida ssp. cordata	—	—	—	—	—	—	+—1	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Dicranella rubra	—	—	+—1	—	—	+—1	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	I
Dicranella subulata	—	—	—	+—1	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	+—1	—	—	—	I
Encalypta vulgaris	+—1	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Species occurring sporadically Gatunki sporadycznie występujące																								
Phascum curvicollum	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Scapania mucronata	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Encalypta contorta	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Thuidium recognitum	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Erythrophyllum rubellum	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	—	I
Tortula ruralis	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	—	I
Barbula unguiculata	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	—	—	I
Pogonatum aloides	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	I
Bryum Funckii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	I
Acaulon triquetrum	—	—	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	—	I
Blasia pusilla	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	I
Lepidozia reptans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	I
Pottia lanceolata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+—1	—	—	—	—	—	—	—	—	I

LIST OF LOCALITIES, WHERE SURVEYS WERE MADE.

The Lublin Plateau:

1. Zimne Doły near Lublin, steep loess wall facing the road to the town. 11 VIII 1959.
2. Zimne Doły near Lublin, steep loess wall. 27 IV 1959.
3. Snopków near Jaszczów (N of Lublin), steep loess wall in the valley of Ciemięgi. 29 IV 1959.
4. Ciecierzyn near Lublin, exposed loess slope near the road to Jakubowice. 7 V 1958.
5. Czumów near Hrubieszów, steep loess slope facing south-east. 4 VI 1959.
6. Izbica, steep walls of a loess slope near the station. 17 VII 1959.
7. Izbica, steep loess wall near the market. 30 IX 1960.
8. Hajowniki near Skierbieszów, loss wall near the road to Skierbieszów. 12 VIII 1960.
9. Ruskie Piaski near Zamość, loess wall. 18 VIII 1960.
10. Sąsiadka near Szczebrzeszyn, loess wall (high) near old ruins. 19 VIII 1960.
11. Gorajec near Szczebrzeszyn, loess wall. 20 VIII 1960.

The Miechów Plateau:

12. Sieciechowice on S side of Miechów, loess wall near the road to Celin. 10 V 1959.
13. Podbrzezie near Książ Wlk., loess wall. 10 V 1959.
14. Szczepanowice, loess wall near river gorge. 17 IX 1960.
15. Podmiejska Wola Górna, near Miechów, loess wall near railway track. 17 IX 1960.
16. Rzerzuśnia, loess wall near the road to Kamieńczyce. 18 IX 1960.
17. Czaple Wielkie, wall in loess gorge. 18 IX 1960.
18. Wrocimowice, loess wall in gorge. 18 IX 1960.
19. Działoszyce, loess wall in the valley of Nidzica. 18 IX 1960.

The Sandomierz Plateau:

20. Sandomierz, Queen Jadwiga's Gorge, southern gorge wall near the exit. 2 V 1960.
21. Sandomierz, Queen Jadwiga's Gorge, southern wall near the entrance. 2 V 1960.
22. Międzygórz near Opatów, loess wall in gorge. 3 V 1960.
23. Klimontów, loess wall. 3 V 1960.